

The Search for ^{271}Mt via the Reaction $^{238}\text{U} + ^{37}\text{Cl}$

P.M. Zielinski^{1,2}, K.E. Gregorich¹, Ch.E. Düllmann¹, C.M. Folden III^{1,2}, P.K. Gupta^{1,3}, D.C. Hoffman^{1,2}, H. Mahmud¹, J.M. Schwantes^{1,2}, R. Sudowe^{1,2}, W.D. Loveland⁴, D. Peterson⁴, M. Schädel⁵ and H. Nitsche^{1,2}

¹ Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720

² Department of Chemistry, University of California, Berkeley, California 94720-1460

³ Department of Nuclear Engineering, University of California, Berkeley, California 94720

⁴ Department of Chemistry, Oregon State University, Corvallis, Oregon, 97331

⁵ Gesellschaft für Schwerionenforschung mbH, D-64291, Darmstadt, Germany

Theoretical calculations show that in the region of the heaviest elements liquid drop fission barriers decrease to zero and the occurrence of nuclear shells is of special importance for the stability of nuclei [1,2]. Experimentally, the influence of deformed sub-shells at $Z = 108$ and $N = 162$ has been confirmed, with the 20-fold increase in half-life of $^{266}\text{Sg}_{160}$ compared to $^{263}\text{Sg}_{157}$ [3], the 300-fold increase of $^{269}\text{Hs}_{161}$ compared to $^{267}\text{Hs}_{159}$ [4] and the recent discovery of $^{270}\text{Hs}_{162}$ [5]. Production of $^{271}\text{Mt}_{162}$ would allow further examination of the $N = 162$ sub-shell.

Additionally, alpha decay of ^{271}Mt would provide more information on ^{267}Bh and ^{263}Db (alpha and sf) decay properties and, should the half-life of ^{271}Mt exceed one second, it might be possible to establish whether Mt behaves as a Group 9 element.

Lighter Mt isotopes were first synthesized in 1982 by Münzenberg et al. [6]. Meitnerium's chemistry has never been studied due to the fact that its two known isotopes (^{266}Mt and ^{268}Mt) have half-lives much less than one second. In order to perform the first chemistry of Mt, a longer-lived isotope needs to be synthesized. Hulet and collaborators attempted such an experiment [7], but were only able to establish a 1 nb cross section upper limit for the reaction $^{254}\text{Es} (^{22}\text{Ne}, 4n)^{272}\text{Mt}$.

HIVAP [8] predicts a reasonable cross section for the production of ^{271}Mt via the reaction $^{238}\text{U} (^{37}\text{Cl}, 4n)^{271}\text{Mt}$ (Figure 1). Targets in the form of $^{238}\text{UF}_4$ are available from Oregon State University, the LBNL 88-inch cyclotron staff can provide a stable and intense ^{37}Cl beam, and 95% enriched Na^{37}Cl is commercially available.

During November 2002 and April/May 2003, the Heavy Element Group at LBNL (in collaboration with researchers from Oregon State University and GSI) attempted to synthesize ^{271}Mt at the LBNL 88-inch cyclotron. Reaction products were separated in flight by the Berkeley Gas-filled Separator (BGS) set to cover magnetic rigidities of 2.15-2.35 Tm. A focal plane detector was mounted at the exit of the BGS to measure correlated EVR-alpha, EVR-fission, and alpha-alpha decays. In addition, a multi-wire avalanche counter (MWAC) was mounted upstream of the focal plane detector to give the first TOF signal, and a Si detector was mounted downstream of the focal plane as a punch-through detector. Both the MWAC and the punch-through detectors functioned to veto uninteresting events (e.g. unreacted beam) in the focal plane. A schematic of the setup is shown in Figure 2.

With a total dose of 4.9×10^{18} particles of ^{37}Cl at 195 ± 3 MeV (Center of Target), no events were seen that can be attributed to the production and subsequent decay of ^{271}Mt . Discounting the upstream detectors, we calculate the upper limit one event cross section at 1.5 pb (shown in figure 1). We plan to run further experiments using 5-10 MeV higher projectile energies to examine the 4n and 5n exit channels. Reducing the MWAC thickness from 3.3 to 2.4 μm should increase the EVR implant energy. We also plan to study the hot fusion cross section systematics using ^{238}U targets.

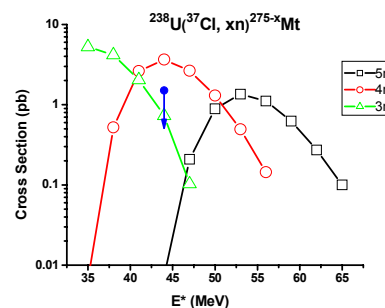


FIG. 1: HIVAP prediction (open symbols) with single-event cross section upper limit shown as a solid circle.

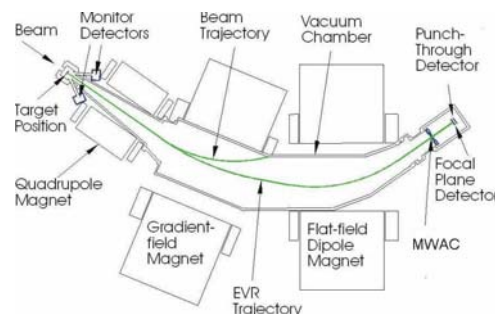


FIG. 2: BGS Schematic.

REFERENCES

- [1] R. Smolańczuk, Phys. Rev. **C56**, 812 (1997)
- [2] S. Hofmann, Rep. Prog. Phys. **61**, 639 (1998)
- [3] R.W. Loughheed, et al., J. Alloy Comp. **213/214**, 61 (1994)
- [4] Yu. A. Lazarev, et al., Phys. Rev. **C 54**, 620 (1996).
- [5] A. Türler, et al., Eur Phys J A **17**, 505 (2003)
- [6] G. Münzenberg, et al., Z. Phys. **A309**, 89 (1982).
- [7] E.K. Hulet, Lawrence Livermore Nat. Lab E&TR, 17 (1988)
- [8] W. Reisdorf, et al., Z. Phys. **A343**, 47 (1992)